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FINAL REPORT-SUMMARY OF RESEARCH
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TITLE: Raman Spectrometer for Surface Identification of Minerals and Organic Compounds on Silicate Planets and Small Solar-System Bodies

PRINCIPAL INVESTIGATOR: Larry A. Haskin
Department of Earth & Planetary Sciences
Campus Box 1169
Washington University
One Brookings Drive
St. Louis, MO 63130-4899

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SUMMARY

Our objectives are (1) to demonstrate that Raman spectroscopy is an excellent method for determining mineralogy on the surface of the Moon, Mars, and other planetary bodies and to demonstrate how well it can be used to discover and identify organic matter; (2) to construct a prototype of a small Raman spectrometer of the kind we suggest could be used on a lander or rover; and (3) to test the ability of that spectrometer to identify minerals, quantify mineral proportions in lunar materials, complex Martian analog materials, and to identify organic matter in planetary surface materials, all under roughly simulated field conditions.

NAGW-5207 covered only the first year of a three-year PIDDP grant, therefore this Summary covers only the first year of work. The principle tasks for the first year were to produce a breadboard sensor head for a planetary Raman spectrometer in accordance with the design submitted as part of our proposal, and to do preliminary tests to confirm that the design is appropriate. We used a laboratory Raman spectrometer to simulate the capability of Raman spectroscopy for on-surface analysis of planetary materials, especially Mars and the Moon. Achievements for the first year of work are described briefly below and were given in detail in our Progress Report submitted in March of this year.

- Parts were purchased and a breadboard sensor head was constructed. We obtained and tested a variety of lasers.

- We have tested the forward and backscatter beam power throughputs and other various aspects of the sensor head performance. We find the initial parameters satisfactory and within our design expectations.

- We have tested the ability of the sensor head to produce spectra of acceptable quality on mineral and rock specimens. After working through issues of laser compatibility and interface between the spectrograph and sensor head, we obtained informative spectra from minerals and rocks.

- We have done sampling depth-of-field testing of our sensor head using objectives with several magnifications and numerical apertures. The results of these tests confirmed that we can use relatively low power objectives (10× to 20×) and still obtain spectra of acceptable quality over an effective depth-of-field of some ±7 mm from the focal point. The results are described in the abstract to the 28th Lunar and Planetary Science Conference (Wang et al., 1997a). The ±7 mm depth-of-field provides good signal for favorable cases, single crystals of quartz and olivine. We anticipate a useful depth-of-field of at least ±3 mm for rock samples, which should be adequate for use with rocks and soils.

- We anticipate opportunities to place a Raman spectrometer on the surface of Mars within a few years. Thus, we have become involved with miniaturization of a Raman spectrometer suitable for flight. We have led teams involving engineers from Kaiser Optical and from the Jet Propulsion Lab to design a flight instrument for two Discovery mission proposals, based on our preliminary design. A good spectrometer of this design can be constructed and flight tested in time for a mission early next century. The design incorporates most but not all of the features we outlined in our proposal. We believe we can incorporate the remaining features we want in time for an actual mission.

- In addition to mineral identification and analysis of peak positions to obtain compositional information, it is desirable in on-surface planetary applications to quantify the proportions of each mineral in a rock. We have demonstrated a method for obtaining mineral proportions in a rock using laser Raman spectroscopy, at low power and with very short acquisition times, by "point counting," using a lunar KREEP basalt as a test case (Jolliff et al., 1996; Haskin et al., 1997). The work was partially supported by the PIDDP grant. In the course of that work, we discovered a systematic shift in peak energy with chemical composition for pyroxene, which we subsequently documented (Wang et al., 1997b).

- In preliminary work, we showed that Raman spectroscopy is a potentially excellent tool for identifying silicate minerals in lunar materials (Wang et al., 1995; Jolliff et al., 1996; Haskin et al., 1997). To demonstrate that such analysis is useful on types of materials we expect to encounter on Mars, we have done preliminary work on a variety of Martian analog materials including carbonates, hydrated minerals, and organic compounds (e.g., Israel et al., 1997a, b; Jolliff et al., 1997).

PUBLICATIONS

Refereed Papers published, in press, or submitted 1996–1997

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